REPORT: Silicon wafer downsizing by Laser-MicroJet®

for Anonymous

by Stephane Delahaye; Synova SA

TASK

The Laser-MicroJet® technology has been tested for downsizing thin and thick silicon wafers.
The goal of this first iteration is to show the feasibility of downsizing silicon wafers and to give a first overview of the cutting quality/process time.

SAMPLE DESCRIPTION AND PREPARATION

Four different wafers were available for the tests:

SAMPLE 1: DMA*	Material	Silicon
	Dimension	Ø59.1 *mm*
	Thickness	~210 *µm*
	Quantity	5 *pc*

SAMPLE 2: ETQB	Material	Silicon and aluminium
	Dimension	Ø84 *mm*
	Thickness	~710 *µm*
	Quantity	5 *pc*

Release of application report			
Project Leader		Responsible Application Group	
Name:	Stephane Delahaye	Name:	Dr Benjamin Carron
Date:	19.11.2012	Date:	19.11.2012
Visum:	SDE	Visum:	BC

SAMPLE 3: ETQB BEVEL	Material	Silicon and aluminium
	Dimension	Ø84 *mm*
	Thickness	~710 *µm*
	Quantity	5 *pc*
SAMPLE 4: GYF*	Material	Silicon
	Dimension	Ø23.25 *mm*
	Thickness	~290 *µm*
	Quantity	1 *pc*
SAMPLE 5: KPZ*	Material	Silicon
	Dimension	Ø43 *mm*
	Thickness	~1400 *µm*
	Quantity	1 *pc*

* The silicon wafers were mounted on semiconductor UV-curable tape.

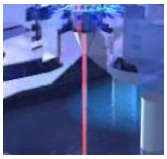
PROCESS: INSTRUMENT & TEST PARAMETERS

For these experiments, the LDS 200M equipped with a frequency-doubled Q-switched Nd:YAG laser has been used as the machine configuration in our lab.
It is a manually loaded machine, allowing to cut, drill, groove, scribe, trench, mark, or grind wafers of any kind of semiconductor material.

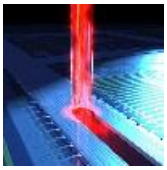
Major advantages of Laser-MicroJet® technology with regards to your application are:

- Cutting of arbitrary shapes
- No chipping on frontside. Minimal chipping on backside
- No heat damage to the material
- Negligible contamination / re-deposition
- Very good wall surface quality

In the table below, the optimized processing parameters used in the experiments are summarized:

	**SYSTEM**	Machine type	LDS 200M
	**MICROJET® PARAMETER**	Nozzle diameter	50 *µm*
		MicroJet® diameter	~42 *µm*
		Water pressure	See results
		Assist gas	He

LASER PARAMETER	Laser type	L51G
	Wavelength	532 *nm*
	Pulse frequency	See results
	Average power	See results



CUTTING PARAMETER	Cutting speed	See results
	Number of passes	See results
	Overall speed	See results
	Cutting time	See results
	Tape	Adwill D-636

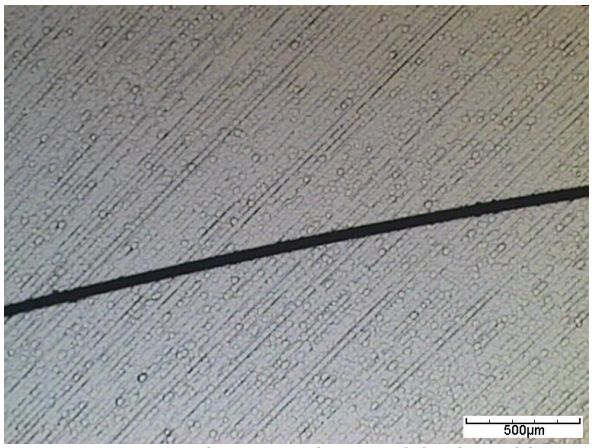
RESULTS

The following microscope picture give an overview on the quality obtained with the Laser-Microjet® technology.

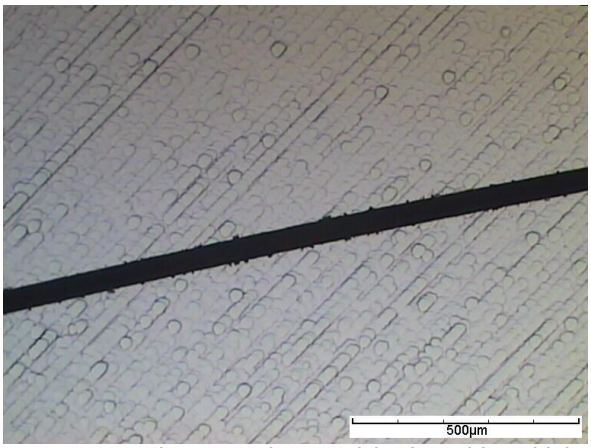
Sample 1: DMA

Five wafers have been processed with the following cutting parameters

MICROJET® PARAMETER	Water pressure	200	*bar*
LASER PARAMETER	Pulse frequency	40	*kHz*
	Average power	~23	*W*
CUTTING PARAMETER	Cutting speed	100	*mm/s*
	Number of passes	6	
	Overall speed	17	*mm/s*
	Process time	~23 (per chip)	*s*



PICTURE 1: Microscope image of the frontside (dark field illumination)

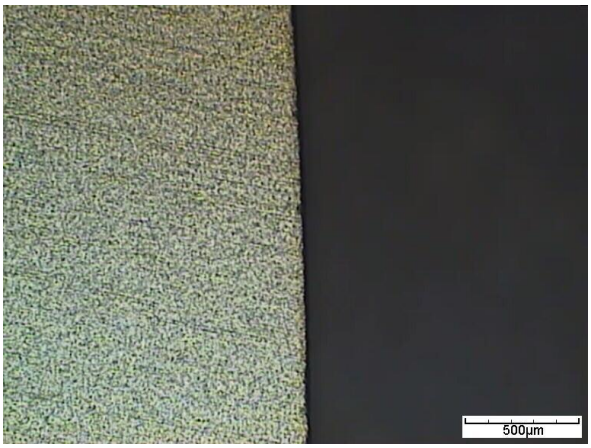


PICTURE 2: Microscope image of the frontside at higher magnification (dark field illumination)

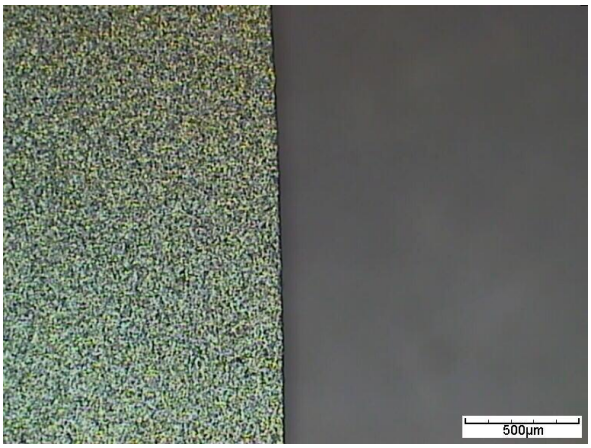
Sample 2: ETQB

Five wafers of 84mm diameter have been processed with the following cutting parameters

MICROJET® PARAMETER	Water pressure	350	*bar*
LASER PARAMETER	Pulse frequency	20	*kHz*
	Average power	~30	*W*
CUTTING PARAMETER	Cutting speed	350	*mm/s*
	Number of passes	~45	
	Overall speed	~7.8	*mm/s*
	Process time	~43	*s*



PICTURE 3: Microscope image of the frontside (dark field illumination)

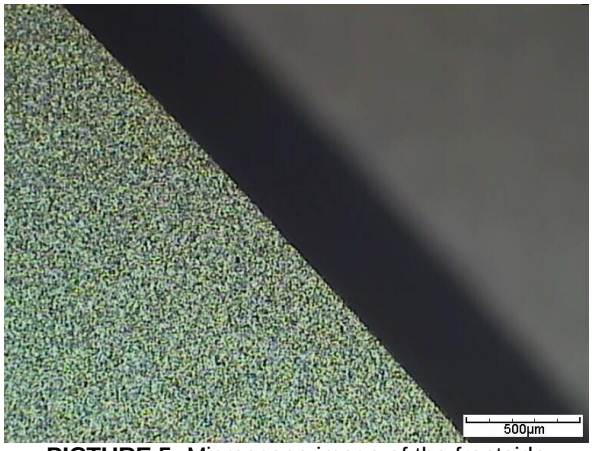


PICTURE 4: Microscope image of the backside at higher magnification (dark field illumination)

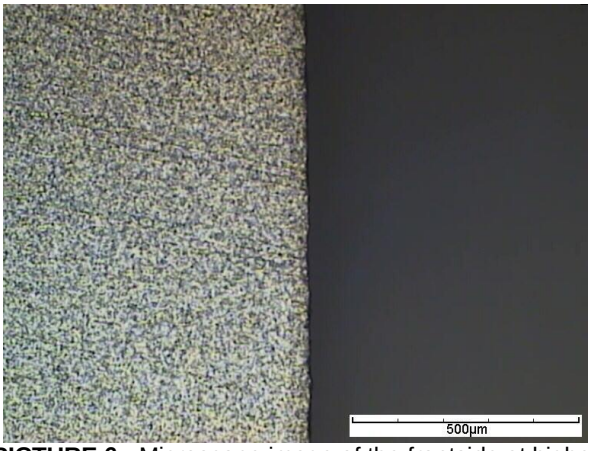
Sample 3: ETQB bevel

Five silicon wafers of 84mm diameter have been cut with an angle of 55° degrees:

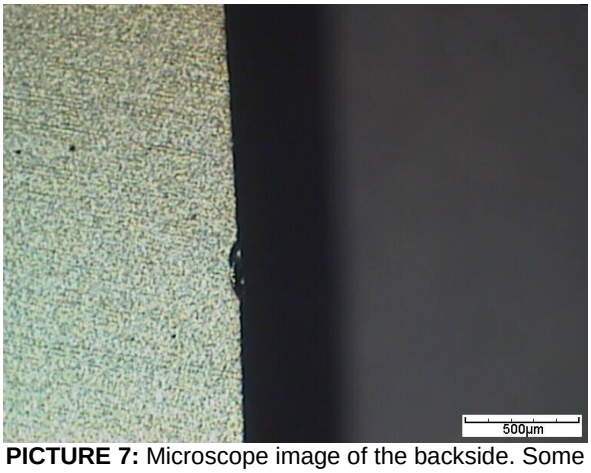
MICROJET® PARAMETER	Water pressure	350	*bar*
LASER PARAMETER	Pulse frequency	20	*kHz*
	Average power	~30	*W*
CUTTING PARAMETER	Cutting speed	350	*mm/s*
	Number of passes	~52	
	Overall speed	~6.7	*mm/s*
	Process time	~52	*s*



PICTURE 5: Microscope image of the frontside (dark field illumination)



PICTURE 6: Microscope image of the frontside at higher magnification (dark field illumination)



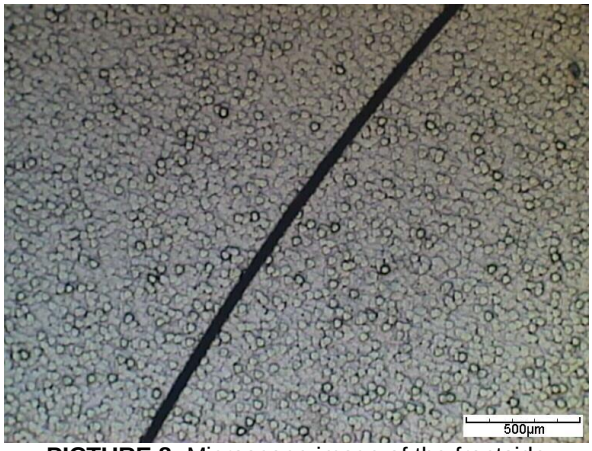
PICTURE 7: Microscope image of the backside. Some chipping is visible (dark field illumination)

Sample 4: GYF

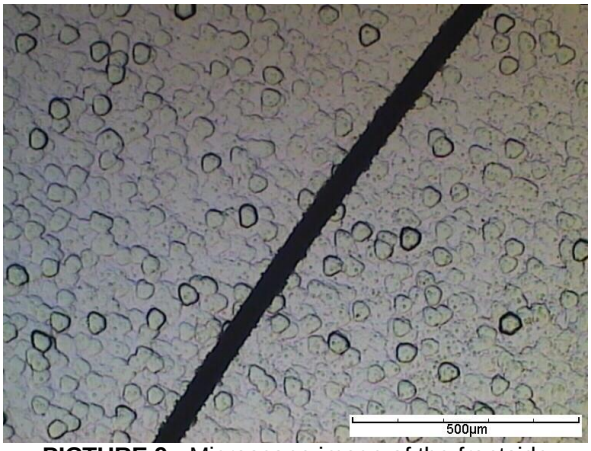
One wafer has been processed with the following cutting parameters:

MICROJET® PARAMETER	Water pressure	300	*bar*
LASER PARAMETER	Pulse frequency	40	*kHz*
	Average power	~14	*W*
CUTTING PARAMETER	Cutting speed	80	*mm/s*
	Number of passes	12	
	Overall speed	~6.7	*mm/s*
	Process time	19 (per chip)	*s*

Please note that two chips labeled with a red cross were used to adjust the number of passes.



PICTURE 8: Microscope image of the frontside (dark field illumination)



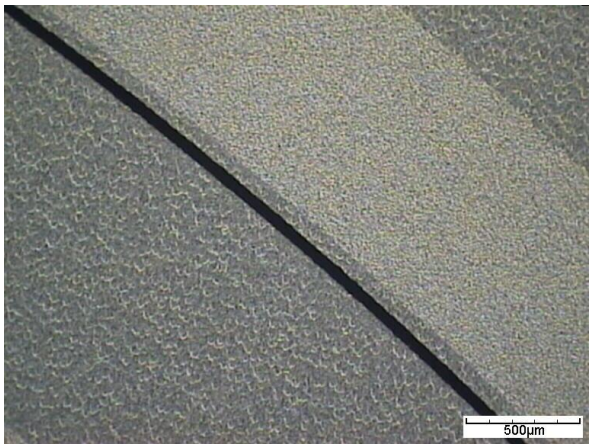
PICTURE 9: Microscope image of the frontside at higher magnification (dark field illumination)

Sample 5: KPZ

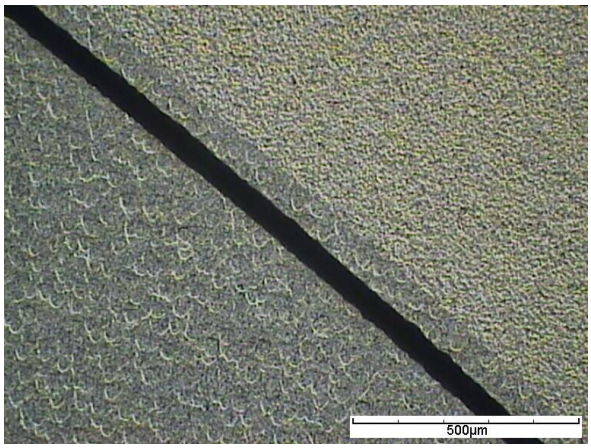
One wafer has been processed with the following cutting parameters:

MICROJET® PARAMETER	Water pressure	350	*bar*
LASER PARAMETER	Pulse frequency	22	*kHz*
	Average power	26	*W*
CUTTING PARAMETER	Cutting speed	100	*mm/s*
	Number of passes	26	
	Overall speed	~3.8	*mm/s*
	Process time	44 (per chip)	*s*

Please note that one chip labeled with a red cross was used to adjust the number of passes.



PICTURE 10: Microscope image of the frontside (bright field illumination)



PICTURE 11: Microscope image of the frontside at higher magnification (dark field illumination)

The table below summarises Anonymous expectations and our results.

	What are your priorities? (please put a cross)	Synova's results
Burr-free:	No attached burr	No burrs
Contamination/Particles:	No adhered debris	No adhered debris
Heat-damage free:	Less than 0.5mm	No heat damage
Chipping/Cracks:	No visible	Minimal backside chipping (~30-40µm)
Edge Roughness:	Must hold voltage after etch process	Needs to be evaluated by the customer

CONCLUSION

The downsizing of silicon wafers was investigated on SYNOVA LDS 200M. This machine is based on the Laser-Microjet® technology and combines the advantages of the high energy pulsed laser with a hair-thin water jet. While the laser is used for material ablation, the water jet is used for guiding the laser light, cooling the edges and preventing the sample from particle contamination, advantages that are essential for cutting silicon wafers with high quality.

These tests show that:

- Cutting thin and thick (combined with a more powerful laser) silicon wafers is possible with high cutting speed and very high quality level. Indeed frontside quality is excellent, cutting edge is very good and backside shows only very limited chipping.

- A high frequency (40kHz) combined with low average power give the best cutting quality for thin silicon wafers.

- Overall speed is increased for thin silicon wafers

Further developments regarding the process time and the backside chipping are possible depending on the client requirements.

We thank you for your interest in our technology and we hope our results meet your requirements. We will contact you soon to obtain a feedback about the analysis of these results and to discuss with you the further steps.